Argument.	Delaunay.	Hansen.	
	$''$	$''$	
$2D-F-3l$	+ 1·5	+ 2·1	
$2D-F+2l$	+ 2·1	+ 2·2	
$2D+F-2l$	− 1·7	− 1·4	
$2D-F+l-l'$	+ 1·8	+ 0·3	Dam. 1″·6; Plana 1″·6; Pont. 1″·6.
$2D+F+2l$	+ 1·5	+ 1·5	
$2D+F+l'$	− 1·2	− 1·2	
$2D+F-l+l'$	− 1·8	− 1·6	
$4D+F$	+ 1·1	+ 1·2	
$2D+F+l-l'$	+ 1·1	+ 1·1	
$F-D+l$	+ 0·4	+ 0·5	
$2D-F-2l'$	+ 1·1	+ 1·1	
$3F+l$	− 1·0	− 1·0	
$2D-F+l+l'$	− 0·8	− 0·8	
$F+2l-l'$	+ 0·7	+ 0·8	
$F-3l$	− 1·6	− 1·6	
$2D-F-l+l'$	− 1·2	− 0·9	Dam. −0″·8; Plana −1″·9 Pont. −2″·0.
$D+F+l$	− 0·6	− 0·7	

A close agreement is found to exist between the remaining small coefficients which are omitted. The coefficient of the term having for argument, Moon's true longitude, is also omitted, as I do not find that Delaunay has given his value of it.

Note on the Ellipticity of Mars, and its effect on the Motion of the Satellites. By Professor J. C. Adams.

One of the results of Professor Asaph Hall's able discussion of his observations of the satellites of *Mars* is to show that the orbits of both the satellites are at present inclined at small angles to the plane of the planet's equator. It becomes an interesting question to inquire whether this state of things is a permanent one. The plane of *Mars'* orbit is inclined to its equator at an angle of 27° or 28°. If then the planes of the orbits of the satellites retain constant inclinations to the orbit of the planet, as they would do if the Sun's disturbing force were the only force tending to alter those planes, their inclinations to the plane of *Mars'* equator, and still more their inclinations to each other, would in time become considerable.

In No. 2280 of the *Astronomische Nachrichten*, Mr. Marth has found the motions of the nodes of the orbits of the satellites on the orbit of the planet due to the Sun's action, and he con-

cludes that, if there is no force depending on the internal structure of *Mars* which counteracts or greatly modifies the Sun's action, the nodes of the orbits will be in opposition to each other a thousand years hence, when the mutual inclination of the satellites' orbits will amount to about 49°.

In this case the near approach to coincidence between the planet's equator and the planes of the orbits of the satellites, which is observed to exist at the present time, would be merely fortuitous; but this appears *à priori* to be very improbable.

It is well known that, if there were no external disturbing force, the ellipticity of a planet would cause the nodes of a satellite's orbit to retrograde on the plane of the planet's equator, while the orbit would preserve a constant inclination to that plane. Laplace has shown that, when both the action of the Sun and the ellipticity of the planet are taken into account, the orbit of the satellite will move so as to preserve a nearly constant inclination to a fixed plane passing through the intersection of the planet's equator with the plane of the planet's orbit, and lying between those planes, and that the nodes of the satellite's orbit will have a nearly uniform retrograde motion on the fixed plane. The angles which this fixed plane makes with the planes of the planet's equator and its orbit respectively will depend on the ratio between the rates of the above-mentioned retrogradations of the nodes produced by the Sun's action and by the ellipticity of the planet. If the latter of these causes would produce a much slower motion of the nodes than the former, as in the case of our Moon, the fixed plane will nearly coincide with the planet's orbit; but if, as in the case of the inner satellites of *Jupiter*, the ellipticity of the planet would produce a much more rapid motion of the nodes than the Sun's action, then the fixed plane will nearly coincide with the planet's equator.

The ratio of the motion of a satellite's node to that of the satellite itself, when the Sun's action is the disturbing force, varies, *ceteris paribus*, as the square of the satellite's periodic time, that is as the cube of its mean distance from the planet. On the other hand, the ratio of the same two motions, when the ellipticity of the planet is the disturbing cause, varies inversely as the square of the mean distance. Hence, for different satellites of the same planet, the motion of the nodes caused by the ellipticity will bear to the motion caused by the Sun's action the ratio of the inverse fifth powers of the mean distances.

Now, the distance of the inner satellite of *Mars* from the planet's centre is only about $2\frac{3}{4}$ radii of the planet, a greater comparative proximity than is known to exist elsewhere in the Solar System, and the distance of the outer satellite from the same centre is only about 7 radii of the planet, while the periodic times of both are very small compared with the periodic time of *Mars*. Hence the effect of a given small ellipticity of *Mars* on the motion of the nodes of the satellites will be greatly magnified.

It is true that the ellipticity of *Mars* is still unknown, and is probably too small to be ever directly measurable; but we are not without means of determining, within not very wide limits, its probable amount, and we shall presently see that, in all probability, in the case of both the satellites the motion of the nodes produced by the ellipticity greatly exceeds the motion caused by the Sun's action, so that the fixed planes for both satellites are only slightly inclined to the planet's equator.

From measures of the planet's diameter and of the greatest elongations of the satellites, combined with the known time of rotation of *Mars* and the periodic times of the satellites, it is found that the ratio of the centrifugal force to gravity at *Mars'* equator is about $\frac{1}{220}$. Hence it follows that if the planet were homogeneous its ellipticity would be about $\frac{1}{176}$. If, instead of the planet being homogeneous, its internal density varied according to the same law as that of the Earth, so that the ellipticity would bear the same ratio to the above-mentioned ratio of centrifugal force to gravity at the equator as in the case of the Earth, then the ellipticity would be about $\frac{1}{228}$. In all probability the actual ellipticity of *Mars* lies between these limits.

The following Table shows the annual motions of the nodes of the two satellites, caused by the Sun's action and by the planet's ellipticity respectively, for the above values of that ellipticity, and also for the ellipticity $\frac{1}{118}$, which has been deduced from Professor Kaiser's observations, although I have no doubt that this value is too great. The Table likewise contains the corresponding inclinations of the fixed planes, so often mentioned above, to the planet's equator.

Satellite I.

Annual motion of the node due to the Sun's action, 0°·06.

Supposing ellipticity =

$\frac{1}{118}$	$\frac{1}{176}$	$\frac{1}{228}$
the annual motion of the node due to that ellipticity will be		
3°·33	1°·82	1°·13
Corresponding inclinations of fixed plane to planet's equator:		
17″	31″	50″

Satellite II.

Annual motion of the node due to the Sun's action, 0°·24.

Supposing ellipticity =

$\frac{1}{118}$	$\frac{1}{176}$	$\frac{1}{228}$
the annual motion of the node due to that ellipticity will be		
13°·4	7°·3	4°·5
Corresponding inclinations of fixed plane to planet's equator:		
27′	50′	1° 19′

From this it may be inferred that the orbit of the 1st satellite preserves a constant inclination to a plane which is inclined less than 1′ to the plane of *Mars'* equator, and that the orbit of the 2nd satellite preserves a constant inclination to a plane which is inclined about 1° to the plane of the same equator.

The ellipticity will also cause rapid motions in the apses of

CHART OF MARS ON MERCATOR'S PROJECTION.

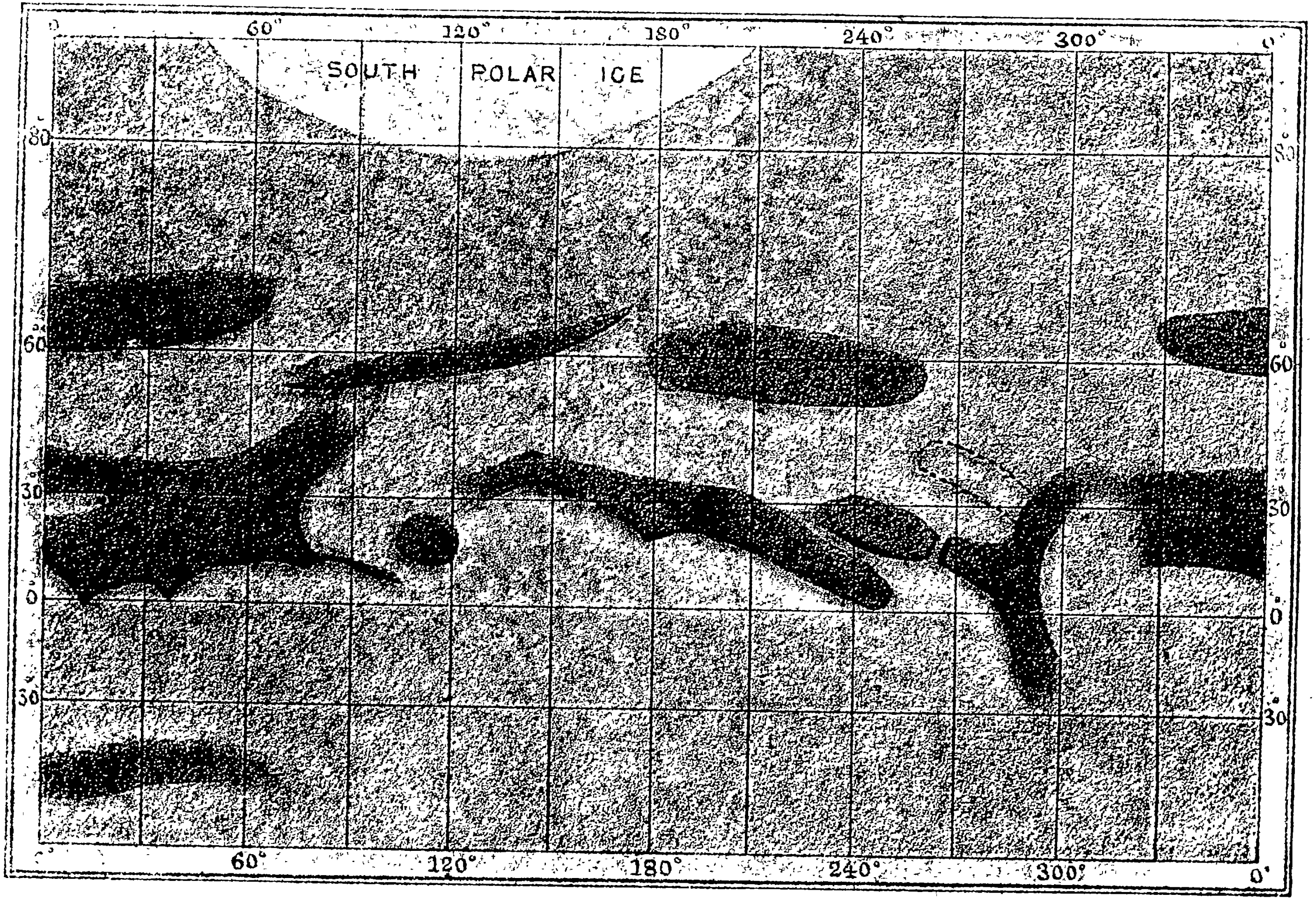

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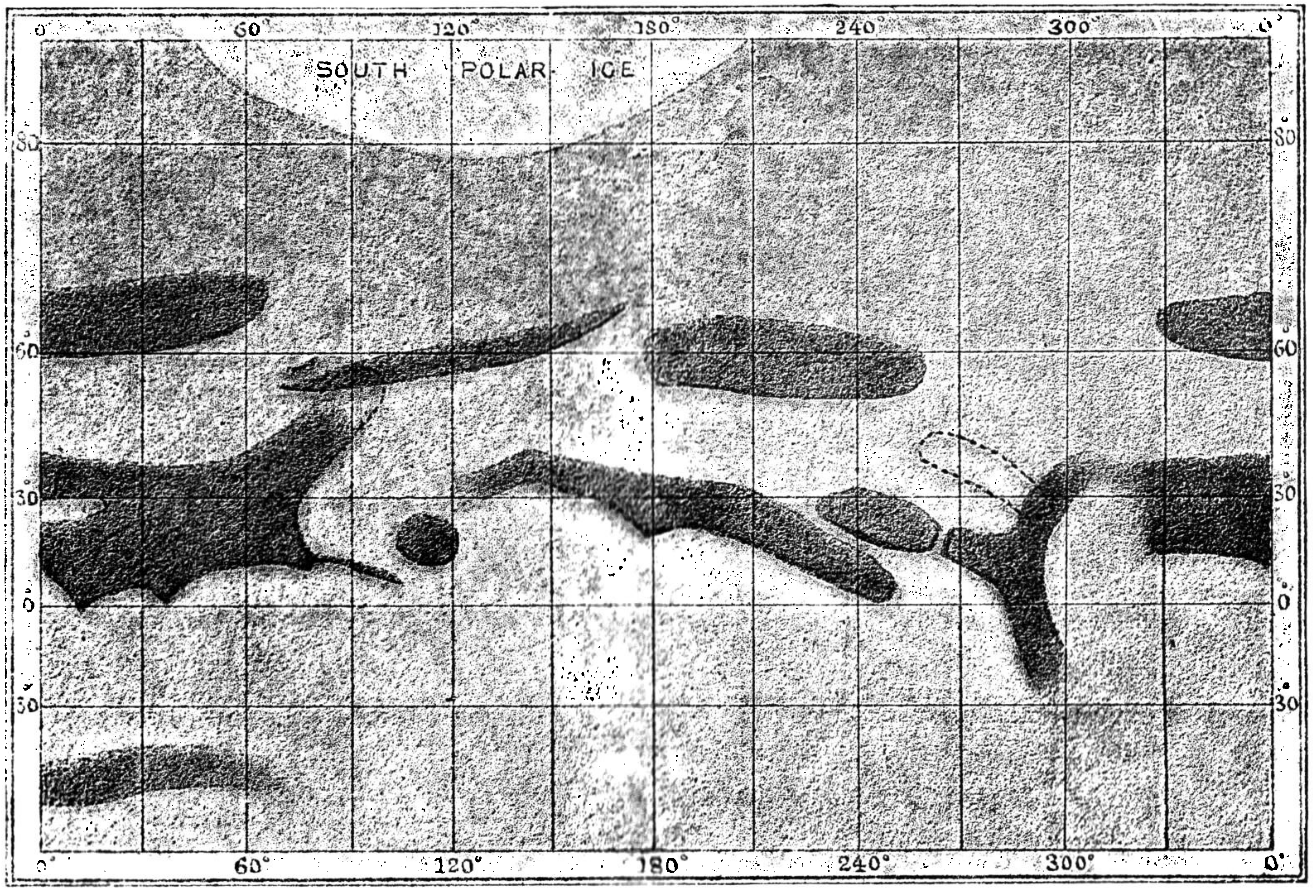
CHART OF MARS ON MERCATOR'S PROJECTION.



the orbits of the satellites, particularly in that of the first; and as this orbit appears from Professor Hall's determination to have a sensible eccentricity, it will be possible, by future observations, to determine the motion of the apse, and therefore the ellipticity of the planet. If further observations show that the orbits of the satellites are sensibly inclined to their fixed planes, the motion of their nodes will supply another means of determining the ellipticity of the planet.

On the Physical Configuration af Mars.

By Professor Wm. Harkness, U.S. Navy.

(*Communicated by authority of Rear-Admiral John Rodgers, U.S. Navy; Superintendent U.S. Naval Observatory.*)

I have constructed the accompanying map of *Mars* from eight sketches taken by myself between August 18 and October 18, 1877. More sketches would have been exceedingly desirable, but the unsteady state of the atmosphere prevailing during the opposition rendered it impossible to obtain them. The telescope employed was the 26-inch Equatoreal of this Observatory. Eye-pieces magnifying up to 400 diameters were tried each night, but it was usually found that a power of 175 gave the best result. This was due partly to the southern declination of the planet, and partly to the bad seeing before mentioned. After each sketch was finished, Professor Hall very kindly compared it with the planet, and in every case he agreed that the sketch showed all that was certainly visible upon the planet, and nothing more. As seen through the telescope, the colour of *Mars* was a golden yellow; except the polar spot, which was pure white, and the markings, which were a light indigo blue.

When laid down upon Mercator's projection the several sketches agreed well with each other, and resulted in the accompanying map; the latitudes and longitudes of which depend upon the Ephemeris given by Mr. Marth in the Royal Astronomical Society's *Monthly Notices* for April 1877, vol. xxxvii., pp. 301–304. The features indicated upon the map by dotted lines were seen only once, and appear inconsistent with other features which were seen oftener. The south polar spot was sensibly circular in form, and, according to my sketches, had a diameter of about $14\frac{1}{2}^\circ$. Professor Hall determined the position of its centre to be latitude, $84^\circ\cdot 8$ south; longitude, 118° west.

Owing to the meagreness of the data upon which it is based, this map cannot be regarded as complete; but it is hoped that it may be greatly improved during the Opposition of next autumn. In its present state it somewhat resembles the map given by Dr. Kaiser in the third volume of the *Leiden Observations.*

U.S. Naval Observatory, Washington,
1879, *June* 17.